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SIMPLIFYING CALCULATIONS FOR DIOPTRIC POWER*

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The general methods used for calculating the dioptric power of surfaces, lenses, systems, etc., involve the use of formulas embodying several fractions. The use of common fractions is made necessary by the fact that the relations between dioptric power and focal length and that between curvature and radius are mathematically reciprocal relations, that is, inverse relations. The longer the focal length, the less is the power; similarly the longer the radius, the less the curvature. Memorizing formulas expressed in fractions and carrying out calculations by means of fractions are processes distasteful to many optometrists and students of optometry, especially if they have not had much mathematical training.

A method that I have used for many years in teaching this phase of physiologic optics partly eliminates these difficulties. It provides an easily memorized formula and involves a knowledge of only the elements of arithmetic and algebra for calculating dioptric powers. For this purpose I have introduced the use of a *unit of curvature* similar to the unit of power. It will be recalled that the early method of numbering lens power, by the inch system involved the use of cumbersome fractions because the power, as the reciprocal of the focal length in inches, had to be expressed as a common fraction. The introduction of the diopter as a unit of power, 1 diopter representing the focusing power corresponding to a focal length of 1 meter, eliminated the use of fractions and greatly simplified the procedure of combining lenses in examining and in prescribing.

The introduction of a similar unit of curvature likewise simplifies the calculations of power, as will be readily seen. I have adopted the term, "metrec"† for a unit of curvature corresponding to a radius of 1 meter

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†This word is the simplest contraction of "meter-curvature," the *c* at the end reminding one, if that is necessary, that it is a unit of curvature. The word sounds strange at first, but becomes perfectly assimilated after one uses it in a few calculations.

(40 inches approximately). A radius of 50 cm. gives a curvature of 2 metrecs; 25 cm., 4 metrecs; 10 cm., 10 metrecs, etc. This is exactly the same as the relation of focal length to diopters. A focal length of 1 meter gives a power of 1 diopter; 50 cm., 2 diopters; 25 cm., 4 diopters; 10 cm., 10 diopters, etc. When the radius is given in millimeters, as for example in calculating the surface powers of the eye, the radius is divided into 1,000 to get metrecs of curvature, just as when the focal length is given in millimeters this is divided into 1,000 to get diopters of power. The anterior surface of the cornea, for example, has a radius of about 8 mm.; its curvature corresponding to this radius is therefore 125 metrecs (1,000 divided by 8).

The power of a surface separating two media can be expressed either by the reciprocal of its anterior focal length or by the reciprocal of its posterior focal length. The usual method is to express it by the reciprocal of its anterior focal length. This, which may be called its anterior power, represents the power of the surface to make incident, divergent or convergent light, parallel after refraction. In brief, it is the power to parallelize light. The power as determined by the posterior focal length which may be called its posterior power, represents the power of the surface to change, i.e., to converge or diverge incident parallel light.

The formula for the anterior power, the one usually taken, is D equals a M; for the posterior power, D=aM/n. These may be easily remembered as two short words, "dam" and "damn." D in this formula represents power in diopters; M represents curvature in metrecs and n represents the index of refraction of the second medium, the index of the first medium being 1. When the first index is not 1, it must be made 1. For example, if light goes from a substance whose index is 1.33 to one of index 1.42, as from the aqueous into the crystalline lens, one makes the first index 1 by dividing it by 1.33. But then one must also divide the second index by the same number, that is, divide 1.42 by 1.33. This gives as the index of the first medium 1.33 over 1.33, or 1, and that of the second medium 1.42 over 1.33 or 1.07. In other words, n in the formula always represents the so-called relative index, which is the second index divided by the first index. This can be taken as a general rule in all cases. To get n, the index to be used in the formula, divide the index of the second medium (to which the light goes) by the index of the first medium (from which the light comes). In this way n may sometimes be less than 1. For example, when light goes from a substance whose index is 1.42 to one of index 1.33, as from the lens into the vitreous humor, the index used is 1.33 divided by 1.42, which gives 0.94. The letter "a" represents the excess of the second (relative) index over 1; it equals n minus 1. The "a" is a reminder that it is the amount *a*bove 1, the *a*dd so to say. Thus if n is 1.37, "a" equals 0.37; if "n" equals 1.04, "a" equals 0.04, etc. Occasionally "a" may be negative; thus, if the second (relative) index n is 0.94, "a" equals 0.94 less 1,

which is minus 0.06.

A few illustrations will now serve to show the method procedure. Suppose one wishes to find the refracting power, anterior power, of the surfaces of the eye. For convenience, whole numbers will be taken for the radii, such as 8 and 6 mm. for the surfaces of the cornea, and 10 and 6 mm. for the surfaces of the crystalline lens. For the index of the cornea one can take 1.37, for that of the aqueous 1.33, for that of the lens (total or equivalent index) 1.42, and for that of the vitreous 1.33. In the formula D equals a M, the following figures are substituted; "a" equals 0.37 (the first index is 1, that of air, and the second index is 1.37, that of the cornea; therefore 1.37 minus 1), M equals 125 (1,000 divided by 8), and D equals 0.37 $\times$ 125, equals 46.25 diopters.

For the posterior surface of the cornea, better considered as the anterior surface of the aqueous, one gets similar data. As the light goes from cornea to aqueous, n in the formula is the relative index of the aqueous, that is, the given index of the aqueous divided by the given index of the cornea (second n over first n). Dividing 1.33 by 1.37 gives n equal 0.97; "a" equals this index less 1, which is minus 0.03; M equals 166.7 (1,000 divided by 6). Substituting these in D equals a M, one gets D equals minus 0.03 $\times$ 166.7, equals minus 5.00 diopters.

It will be noted that the posterior surface of the cornea has the effect of a concave lens. For the anterior surface of the lens, n equals 1.42 divided by 1.33, which is 1.07 "a" equals 0.07 (1.07 less 1) and M equals 100 (1,000 divided by 10). D therefore equals 0.07 $\times$ 100, equals 7 diopters. Finally for the posterior surface of the lens, or rather the anterior surface of the vitreous, n equals 1.33 divided by 1.42 (second index over first index), or 0.94; "a" equals minus 0.06 (0.94 less 1), and M equals minus 166.7 (1,000 divided by 6). The curvature here is minus, as the surface is concave to the incident light. The result will be plus, as the minus of "a" is multipled by the minus of M. D equals 0.06 $\times$ 166.7, equals 10 diopters.

In a similar manner the posterior power of any of the surfaces, and of course the surface and combined power of thin lenses, mirrors, etc., can be calculated. All this is readily accomplished by noting the two simple formulas, which are easily remembered as dam and damn, and by understanding the significance of the four symbols used. In conclusion, I may add that I have seen men who had a dread of mathematics and the sight of optical formulas take up this method and master it within an hour or two.

It may be added that the above calculations involve the use of the actual focal lengths as the measure of dioptric power. The introduction of the theorem of reduced focal length would somewhat modify the above calculations, though the method would be similar.

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THE DIAGNOSIS AND CORRECTION OF FUNCTIONAL MYOPIA*

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Optometry has been greatly concerned of late with myologic techniques and methods of diagnosis of ocular anomalies other than refraction, namely those of muscular imbalance. We have learned much of these anomalies, but there is a great deal which still seems a mystery. A consideration of the methods involved in enabling us to further understand Functional Myopia, both as to its diagnosis and its correction, is not untimely. The reader is reminded that in this paper, the types of myopia which are pathological are not included. True or structural myopia is to be thought of as a true static condition, while in functional myopia, the entire error may be a dynamic state, or partly so in cases where the true myopic error is augmented by some functional myopia. The purpose of this paper is to give a unified method of distinguishing the presence of this type of error and its correction.

Etiology. The current opinion of many practitioners concerning the cause of functional myopia is that an imbalance of the visceral organs is responsible. While I accepted this explanation for some time, it is impossible for me to do so now. If this were the case, how would our corrective treatment work with the convergence and accommodation affect the viscera sufficiently to remove the cause of the error?

The explanation which has occurred to me is found in the realm of physiology, and the same state of partial contracture can be obtained experimentally in the laboratory. Continuous close application without sufficient ocular relaxation at intervals and improper rest at night seems to be in a large measure responsible for the condition. The ciliary muscles being under constant stimulation for long periods are apt to remain in a state of "partial contracture" due to the accumulation of waste products. The muscles have not relaxed in full before another long period of stimulation begins. It takes only one diopter of functional myopia to shorten the ocular focus from infinity to forty inches, and to reduce visual acuity from normal to 20 per cent or less. It is the relaxation which we must force in the correction of these cases. To give the patient the

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apparent correction which he shows would only add to his discomfort, and be the cause of a further increase in the condition.

There is a type of case which shows most of the symptoms of functional myopia, but which is merely one of simple convergence tension unaccompanied by accommodative stress. When the same method of treatment is followed, the myopia is found to be the same as originally. This type will be considered in the section on diagnosis as to its differentiating features.

Diagnosis. There are several tests, observations and correlations that can be made to enable one to ascertain the presence or absence of functional myopia. These tests follow.

(a) The uncorrected vision is reduced to a greater extent than would be expected for the amount of the error. Many cases showing the apparent need of a minus .50 diopter sphere will not be able to read characters smaller than the 20/100 size.

(b) Pupils are much smaller than are common to true myopia. It is due to the constant action of accommodation.

(c) With the apparent distance correction in the lens cells, the distance abduction tends to be low in most cases. (Six to eight prism diopters.)

(d) The negative relative convergence test for distance using a vertical row of 20/30 letters shows the presence of some positive accommodative action, when there should be very little. In this case, the row of letters begins to blur very soon after base-in prism power is added. In this test the blur should occur just before the breaking point. Most cases with the true static correction will declare these two points to be practically simultaneous.

(e) The distance phoria test will indicate the presence of hyperconvergence. Absolute lateral orthophoria for distance is actually an overconvergence of approximately one prism diopter. In functional cases, esophoria will be present in a great majority.

(f) Near point convergence analysis is of great value in this type of case. The method, in brief, of making this test follows. Diplopia is produced by placing a vertical prism over one eye. Fusion is thus broken, and the fusional convergence which was in force to maintain single binocular vision can be measured by prism base-in. (This is the near exophoria.) Do not consider any physiologic condition, but, figure the amount of the base-in prism as the fusional convergence. Do not hurry the patient, and make prismatic changes with the patient's eyes closed. Then add the plus spheres over each eye that will give an automatic focus for the testing distance, as plus 3.00 spheres for thirteen inches. This eliminates the normal accommodation to the target, and again the images will have to be aligned by more base-in prism. This amount over and above that found as a measure of the fusional convergence is the accommodative convergence relaxed by the plus element. In many functional

myopes there will be but little, if any, fusional convergence present, and the accommodative convergence being used entirely to maintain single vision. There may be an actual over convergence of the accommodative type, indicated by an actual esophoria, in which base-out prism must be used to obtain alignment of the images. The diagnostic points here are not only lack of fusional convergence, but a very low total of both types as compared with the theoretic total. The Theoretic Total Convergence to that point may be figured easily. Multiply the interpupillary distance in centimeters by the meter angles of convergence necessary for one eye to that point (three for thirteen inches) and add the distance exophoria. I do not subtract the distance esophoria, because that is not a true condition, but evidence of tension. If there is any great discrepancy between the total convergence which we have found and the theoretic total, it is indicative of tension, and proves to be one more link in the chain of evidence of functional myopia. Two to three prism diopters may be considered as error.

(g) The near abduction will be found low in functional cases This condition again points to hyper-stimulation. And in this test, as well as in the convergence analysis, there is a theoretic total which must be compared with that found. The theoretic abduction is the convergence necessary to the testing point as explained above, plus the distance abduction. For example, a case with six centimeter interpupillary distance needs eighteen prism diopters of convergence for 13 inches (as explained previously in this paper). The distance abduction was eight prism diopters, which must be added to the convergence necessary. The total is twenty-six prism diopters which is the theoretic near abduction at thirteen inches. If, for example, the case under consideration is able to abduct only sixteen prism diopters, there is a great discrepancy, and, once again, we see signs of the stresses and tensions found in functional myopes. Error can be taken as two to three prism diopters.

(h) The negative relative convergence at near will be low. This type of convergence should be within two or three prism diopters of the amount of convergence necessary for the testing distance as explained before. If the blur of the characters is noticed before this point, tensions are indicated. The lower the blur point, the more the functional myopia. Be sure that the patient informs you of the beginning of the blur, and have him fix small letters for this test, so that blur will be noticed easily.

(i) The F-L test can be made with the Wells cards or Kratometer. The Wells B series is of value likewise. These cases of hyperstimulation will see the letters as F-L and not as an E. In the B series, the patient will see the arrow over Nos. 3, 4, or 5 instead of over No. 6.

(j) Negative relative accommodation is apt to be higher than normal, showing an over-correction for distance.

Functional myopia is most often found in adolescent children who are doing a lot of close work, but it may be found later on in life as well. The farther advanced in age, the less we are apt to find this anomaly

in our cases. I have had several early presbyopes who were in just such a condition at the age of forty-two or forty-three.

There is a certain class of myopes who show most of these symptoms of a functional condition, but who are actually in a state of simple convergent tension. In these cases, the myopia cannot be reduced, but the patient is benefited greatly by convergence relaxation measures. These patients will have larger pupils than functional myopes, the blur points will be closer to normal, and these are about all the differentiating features we can find.

Latent hyperopia will be accompanied by many of these same anomalous conditions which are mentioned here in connection with functional myopia. The two errors are very closely allied as to cause, both being due to over-stimulation of accommodation and the resulting state of partial contracture and tension in the medial recti.

Method of Correction of Functional Myopia.

In all these cases we are dealing with tensions and stresses of the accommodation and convergence. The nature of our corrective procedure should be such that will provide a relaxation of both these functions.

(a) *The Lens Correction.* The correction to be used is that which was found objectively and subjectively which gave the best acuity the patient was able to achieve—less a half diopter. Do not fail to reduce the apparent minus correction this amount. If the patient was capable of 20/20 or 20/16 vision this reduction in minus sphere will reduce the acuity to approximately 20/30.

(b) *The Prism Correction.* I do not include the prismatic element in the minus correction, but have a separate series of toric, plano prisms for fitover frames. These are worn over the lenses as much as possible, and particularly for all close application. The amount of base-in to prescribe is about two-thirds of the total breaking point of the distance abduction. This value is chosen because it is not too close to the breaking point to cause trouble. The method most common at present, I believe, is that which was advocated by Peckham, which is the point of the return to fusion. In many cases this point is almost simultaneous with the diplopia point, so it is not as advisable as the two-thirds value. As the patient's convergence begins to relax, the prisms can be increased in strength. By having a supply of these prisms in two, three, four, and five prism diopter strengths, we can make these changes whenever desirable. They must be carefully fitted to the individual cases so that the bases are in the exact position, otherwise we are apt to induce vertical strain.

(c) *Instrumentation.* There are many devices in use today which can be used successfully for the relaxation of these tensions. The best ones in my practice have been the Wells or Kratometer techniques, and the Squint Korrector. I have not tried the Myologic unit or the Stereo-Orthopter on these cases, but see no reasons why they could not be used

with success. One thing is essential, convergence and accommodative relaxation. It does not make a lot of difference whether the instrument has revolving gadgets, flashing lights, or moving mirrors. If it will aid in obtaining this nature of relaxation, it will do. With the fixation target of the Squint Korrector at 20 inches I use a plus one diopter sphere O. U. over and above the distance correction. This aids the accommodation as the base-in prism aids in convergence relaxation. The amount of base-in prism is kept just below the diplopia point throughout the treatment.

(d) *Treatments.* The treatments should be at least three times a week, and oftener if possible. The muscle tests and acuity tests are made before the start of each treatment. The patient will have better acuity if the treatment room is illuminated. This is due to the fact that the pupils are slightly contracted by the light, and the extra-axial rays are partly cut out, giving more of a point focus and less of a caustic curve focus. As the patient is able to pick out the 20/20 line, reduce the minus correction another half diopter. He must always have something to work for. You will get no farther if these reductions are not made when necessary. My treatments after the first few run about forty-five minutes including the muscle test.

(e) *Bifocals.* The only cases on which I use bifocals are those who cannot come in three times a week. They have the auxiliary prisms in the fitover frame as well. I believe it is Peckham who advocates the use of bifocals in certain cases, wherein the addition of plus to the distance correction increases the near abduction, either the break or the return. If such is not the case, bifocals are not to be used.

(f) *Records.* All of the records of these cases I keep in graph form. (See Graphical Case Records—American Journal of Optometry—Volume 9, No. 8.) These records are of utmost interest to the patient, as well as being the most visible of all types of records to all concerned. Try them and see for yourself.

The return to normal of the muscular system will indicate the time for termination of the corrective work. The final lens correction is to be given at this time, and the patient advised of the following necessary measures for eye care:

1. Not to work under glaring light.
2. To rest and relax the eyes from close work every hour.
3. Not to do close work too near the eyes.

The cases should return for a muscular and visual check every two weeks for a period of two months, and again at the six month period. It is surprising that very few of my cases of this nature have suffered relapses. Most of them are in better condition after the six month period than before.

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A STUDY OF THE EFFECTS OF LENSES ON THE HEART BEATS AND BLOOD PRESSURE*

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It is with considerable hesitancy and trepidation that the results of this study is offered for publication. The writer is well aware that the results of this study are startling and will be doubted by all except those few who have made a thorough study of the Central Nervous System and studied the effects of their prescriptions on the Central Nervous System.

Since the winter of 1928-29 we had observed that many of our Myopic treatment cases, and many hyperopes undergoing base-in treatment, who had a low pulse rate and low blood pressure when the treatment was started, gradually built up normal blood pressure and normal pulse rates as the eyes were relaxed. No great stress was laid on these findings as we all know progress in reducing Myopia is comparatively slow, and other factors might enter into the change of pressure and of pulse rates.

In the summer of 1930, however, our attention was forcibly directed to the fact that lenses really do affect the pulse rates.

At that time we were giving a base-in with plus treatment, with an instrument similar to the Squint Korrector, when our patient remarked, "I will have to take a rest as my heart is running away with itself." Complying with his request, treatment was stopped and his pulse counted. Imagine our surprise to find a pulse of 152. Treatment was resumed after a few minutes' rest, but with weaker spheres and weaker base-in prisms and a careful check made of his pulse. These weaker lenses brought the pulse to 100.

The next day the stronger lenses were again tried with the same result, so our work was finished with the weaker lenses.

A study of our Neurology explained the phenomena as we find (Eppinger and Hess, Vegetative Nervous System) that the Sympathetics control the dilatation of the pupil, the contractor fibres of the ciliary and also carry nervous energy to the heart causing it to beat faster. That the

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Autonomics energize the circular fibres of the ciliary and also slow the heart rate.

Needless to say, from then pulse rates were carefully checked on each treatment case at least every ten minutes during the treatment.

Not all, of course, responded and none since have approached the case that originally attracted our attention. Most, however, responded with an increase of four to fifteen beats per minute while taking base-in with plus treatment.

Observation of many cases was necessary to form any opinion of the reason of the variation. Tabulating the first hundred cases it was found that those showing the greater increases had full sustained binocular single vision. Those showing the smaller increases possessed sustained binocular vision to a lesser extent, and those showing no increase could not sustain binocular single vision for any appreciable length of time.

It was also noted that the patients showing the greater change in pulse rates responded more quickly to the particular type of treatment given them.

Since the variation in pulse rates followed so closely the strength of desire for sustained binocular single vision, we reasoned that our more rapid progress with treatment cases, exhibiting the greater change in pulse rates was due to the continuous effect of the lenses where binocular single vision was constant, thus giving the full irritating effect to the sympathetics, and that suspensions, no matter how slight would nullify to a certain extent the effects of the prism in particular.

In our study of the Central Nervous System to account for the increased rapidity of heart beats, while treating with plus spheres and plus prisms, we noted (Eppinger & Hess) that the "Spinal Sympathetics carry nervous energy to the Arteries and Abdominal Viscera, keeping the muscles in their walls in a slight tension, preserving or lowering blood pressure."

Naturally, our next step was to investigate the effects of lenses on the blood pressure. At first we did not feel free to experiment with patients whose pressures were above normal, as we considered it our duty to immediately refer them to their family physician, so our earlier experiments were wholly with patients whose pressures were normal.

In my notes of a year ago I find the following: "Blood pressure is not so easily demonstrated, as it is not unusual for the pressure to vary a few millimeters in a short time. We also find many patients that it is impossible to definitely state within two or three millimeters just what their pressure is."

However, we were able to find many who, under Korrector treatments with plus spheres and base-in prisms, we would get a definite raise of from three to seven millimeters. Reversing the process we would get a lowering of three to five millimeters making a total spread of from six to fifteen millimeters. Others did not show any appreciable change.

These results were encouraging enough so that we made a practice of prescribing for our high pressure cases a slight undercorrection of the spheres and incorporating a modest base-out prism effect, usually by decentering, with apparently pleasing results.

In January, 1932, however, while my wife was taking her yearly general physical examination, it was found that she had developed a Systolic pressure of 275 millimeters, with an absolutely perfect physical condition otherwise.

Of course, her physician put her to bed giving her sedatives to bring down the pressure a bit, and keep her somewhat satisfied with her lot. But with the cheerful information that there "would be no more work or social activities in her life" after a week of this she rebelled and decided she was going to pursue, to a certain extent, her normal life regardless of consequences.

By this time I had gotten over the shock of finding her in a serious condition, instead of the perfectly normal healthy woman I had supposed her to be, so had her come to the office, rest for a couple of hours for the effects of the exertion to wear off, then with her physician in attendance, taking the pressure carefully at first, then giving twenty minutes of base-out prism treatment and taking the pressure again to find it thirty millimeters lower.

Assured by the physician that "this is fine and cannot possibly do any harm," these treatments were continued for a few days, only to find that their effects wore off within an hour after treatment; so we must do something else if we were to hold the pressure down at all times; at first the prescription of base out prisms with a reduction of her plus spheres seems to be the proper procedure, but that didn't look so good to me.

Fortunately in our study of the association of the verticals with convergence-accommodation had taught us that we might very well get the same stimulation of the nervous system through that source; here we found a really powerful stimulation as thirty minutes with ten diopter base-up prisms brought the pressure down from 250 millimeters to 160 millimeters and also brought on a fine case of hysterics, that took her until the next day to get over.

Our next experiment was with one dioter base-up. Not finding this strong enough we gradually built up to five diopters base-up until after three weeks of wearing these various prisms in fitovers it was found that three diopters base-up combined with —.75 spheres would bring the pressure to about 160 millimeters and hold it there without any noticeable discomfort.

These were prescribed by reducing her plus five spheres to 4.25 combined with three diopters base-up prisms. We also used kryptok segments instead of Ultex, giving us further base-up effect in the segments and these were ordered without the usual displacement in, giving

here one and one-half diopters base-out for reading. Constant wear. By the last of February the pressure was 145 millimeters and has remained in that neighborhood since, with the exception of a week in May when we took off the special lenses and had her use the old prescription and found the pressure up to 175 millimeters. So we returned to our special correction until August 15, when they were again removed and a return to the regular glasses. Up to the date of this writing, September 6, there has been no raise in pressure.

Early in March we were induced to take on another patient who, with her physician in attendance, exhibited equally pleasing results; keeping her under observation for four days at the office and at my home we were satisfied with bringing her pressure down from 290 millimeters to around 200 millimeters and prescribed her regular correction with four diopters base-up prism. Her doctor thought 200 was her zone of comfort.

This case was over ten years standing; has very little association of the verticals with convergence-accommodation, in fact shows but one diopter less exophoria in the reading position than in the horizontal and only a quarter diopter less plus in the reading position than in the horizontal, while Mrs. Parkins shows four diopters less exophoria in the reading position than in the horizontal and requires .87 diopters less plus in the reading position than in the horizontal.

Encouraged by these results and the assurance of the different physicians we could not possibly produce injurious effects by bringing down the pressures. We made four more prescriptions of like nature during March and the first week in April, all in cases where the association of convergence-accommodation with the verticals was fairly strong, with satisfactory lowering of pressures in each of the four cases, one from 205 to 165, another from 190 to 150, another from 185 to 135 and another from 175 to 140.

We felt that we should observe these six patients for a few months to check against any possible undesirable developments.

Our investigation could continue, however, without further permanent prescriptions. So in all high pressure cases calling at our office we have tried different prism position, base-up and out, etc., but with no further improvement on our original base-up position.

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A PECULIARITY OF COLOR VISION*

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Recently, I was quite surprised, on looking at a green card through a stereoscope to find that the tint of green appeared quite differently through my left eye than through my right eye.

At first I thought that this must be due to a difference in the absorption of the two lenses of the stereoscope. So I reversed the instrument thus interchanging the lenses before my eyes. The difference in tint was still apparent. So that threw out the postulate that the apparent difference in tint might be due to a difference in absorption in the lenses.

I then tried a number of other colors, red, yellow, blue, violet, and so on, but with those I found no difference between the hue, or tint, as it appeared to each eye separately.

On returning to the green card, I found that the tint, as interpreted by binocular vision was of a still different hue than that seen by the right eye or the left eye.

The salesman who was demonstrating the stereoscope told me that he had found a number of people who stated that they had the same or similar experience in noting that the hue, or tint, interpreted by one eye was different from that interpreted by the other eye.

We have long realized that when one person says he sees a red object that his interpretation of that red is not necessarily the same, or identical with, another person's interpretation of red. But to find that the same person varies in the two eyes in his discrimination of tints, is quite a surprise. I do not believe that this has ever been a matter of record. It certainly would be a subject well worth investigation by those who are studying the problem of color vision.

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OPTICAL CONTROL OF THE CENTRAL GRAY*

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Instead of attempting the Herculean task of pursuing absolute truth to its finality it shall be the purpose of the writer to cite material from many sources supportive, if nothing more, of certain obvious inferences to be drawn in this paper.

There exists in the minds of many optometrists a considerable confusion as to just what the scope of practice may be. There are two wings, each quite certain that the viewpoints held by adherents is the correct one, and both inclined to considerable rancor and exhibiting at times rather heated contentions for their respective viewpoints. Since this paper has to do with a specific phase of this issue, it appears to be policy at the beginning to set forth the position of the writer relative to the present controversy. When he was asked to accept membership on a committee of this Acamedy, then known as the committee on physical thearapy, he accepted the appointment in part conditioned upon a more fitting name for the committee, he at that time holding that the word "therapy" had no place in optometric literature so long as it was defined as a non-therapeutic branch of physics by statutory enactment in most states. He made the suggestion that the name of the committee be changed to The Committee on Physical Agencies, which name was adopted by then Chairman Koch, and which decision was without doubt influenced by discussion of the suggestion with Dr. Kurtz, chairman of the committee.

This committee has been functioning for two years, and has reported to this Acamedy. The writer has sent practically no material to the committee chairman because a great portion of the research work he has been doing has concerned itself with admitted therapeutic agencies such as diathermy, galvanism, ultra-violet and other agencies commonly used for the treatment of pathologies, and so recognized. His reason for refraining from sending case reports of these cases is that he could not report them as purely optometric patients. The legal definition of

*Material presented before the American Academy of Optometry at Omaha December 16, 1930.

optometry in most states does not permit the use of electricity and electrical energy for therapeutic purposes on the eyes or elsewhere on the body, except by those duly licensed so to do. While the writer admits that he wrote the chapter on galvanism for optometrists for Dr. Kurtz's book, he now believes that to have done so was of doubtful propriety and may cause some optometrist to run afoul the medical practice acts of his own state. This latter statement is made following a rather careful survey of the statutes of the several states as they pertain to the practice of optometry. The book under discussion will serve a most valuable end to research students and will doubtless become a constant companion of those optometrists who under the terms of their state laws may legally make use of the valuable material contained therein, but it may cause some optometrist to overstep his legal bounds. So far the statutes of only two states have been found which might be so construed as to permit an optometrist all the liberties of the use of physical therapeutic apparatus generally.

As long ago as 1920 this writer in an editorial supported the idea that optometrists would eventually deal with pathologies of the eye in a manner comparable to dentistry, so he cannot be accused at present of being a reactionary, but experienec has shown that all too often the improperly trained man is the one who first seizes upon new things, and not having sufficient background very soon ends by causing serious damage to some patient, or perhaps causes some other less capable individual than he to undertake the use of agencies which in the hands of the unskilled and untrained are capable of doing irreparable damage. The unquestionable present trend is toward broadening the practice of optometry, yet it seems imperative at this time to voice a strong protest against permitting individuals to undertake the use of certain possibly dangerous physical agencies, unless and until they have pursued a carefully prepared course of preliminary groundwork instruction. To merely tell an optometrist *what* to do is *not* enough. He must be taught *why* he does it and then only can he safely be permitted to dabble with energies as potent as some of our modern physical agents. This statement would be just as true in principle if every state in the union were to adopt liberalizing legislation with reference to optometry at the coming legislative sessions.

At present, legally and by birthright, optometry consists of the proper preparation of light within the so-called visible range. Therein at present lies its field. And *that* field is so full of possibilities that the writer hardly knows just where to begin with a presentation of the subject. The anatomy of the brain and nervous system as they apply to the visual functions has already been presented by *Dr. Wiseman* [1], [2] and you are presumed now to be well grounded in this subject for the purpose of this paper. It were sheer folly to attempt to supplement or to

[1]E. G. Wiseman. The Evolution of the Visual Apparatus. American Journal of Optometry. Vol. 6, No. 8, pp 455-471.

[2]E. G. Wiseman. A Study of the Visual Portion of the Autonomic Nervous System. American Journal of Optometry. Vol. 7, No. 12, pp 645-654.

amplify what has already been said on that subject. In what follows an attempt will be made to utilize your present knowledge of the nerve tracts and connections involved, to present to you some factors which it is hoped will at least intrigue you into a further study along the lines suggested. Regardless of the apparent ramifications and ramblings which are to follow, you are cautioned to keep in mind this one fact, and that is, that any physiological reactions mentioned are obtainable by the use of light well within the so-called visible ranges, and that all applications were made through the eyes.

The question as to just what constitutes light, vision, seeing and like relative terms may be and is one to be decided by the physicist, the physiologist or the psychologist depending upon just what idea is meant to be conveyed by the word in each case. Regardless of the respective decisions we must admit that physics cannot be ignored, neither can the anatomical paths of conduction, the reflexes involved or the final mental process be omitted, and retain the visual function. All must be considered.

A beginning shall be made by a brief discussion of a certain physical principle which has been wholly overlooked in the practice of optometry by most, if not practically all optometrists, the *energy content* of light. To say that white light is made up of a mixture of all the colors in the visible spectrum is but a blunt admission that the speaker is totally ignorant of modern thought in light physics. To say that certain wave-lengths when combined can make white light may be true, but the white energy is *not a mixture*, it is a resultant, and may not, and quite likely does not, possess periodicity—a necessity for each wave-length in a *mixture*. The resultant may be, and modern physics holds it to be, an "impulse" of irregular form. The train of impulses is capable of having periodicity impressed by a number of well known physical operations, i. e., passage through a prism, reflection from a grating, transmission through a grating, or multiple reflection and refraction combined by minute irregular or spherical particles such as water vapor, smoke or metallic oxides in suspension in highly viscous semi-solids.

In clarifying the method of enforcement of periodicity on initial impulses, an analogy in sound physics similar to the effect of a grating is found in the simple experiment of standing at the head of a long uncarpeted stairway in a large hallway, then clapping the hands to send forth a single impulse of sound. The reflected sound waves from the steps in the stairway return to the ear of the experimenter as a note of musical quality and having a definite pitch, which latter is, however, determined by the "rise" of each step, the temperature of the room and other factors. Here this single impulse of energy by multiple reflections from the surfaces of each step echoes back to the starting point, each echo from the next lower step being evenly spaced in time interval from that of the step above, thus fixing a definite periodicity. The grating

operates in much the same manner. Fog, smoke and metallic oxides in suspension presumably operate in accordance with the older physics textbook explanations, by internal reflections and surface refractions. Fog and smoke cause continuous spectra to be seen while in the case of metallic oxides usually all frequencies are absorbed in part while others are freely transmitted, or reflected.

Just at present writing, the literature and the advertising pages of our professional journals are filled with dissertations on the value of glare removal, with the always added bit of free advice that certain lenses are best suited for that purpose. Such lenses must depend upon whatever effect they may produce *physically* upon some one or more of the principles just discussed. But what happens physically and what takes place *physiologically* are far different things. Our behavioristic friends would have us believe that the human organism is nothing other than a group of physico-chemical processes, a chemical machine. Yet because *Lillie* has been able to immerse an iron wire in acid, and found that it functions in a manner quite similar to the impulse discharge rate of a human nerve does not prove that nerves are made of iron, nor that there is no other purpose in life than to receive or transmit impulses according to certain pattern habits. *Lillie's* iron wire can be made to exhibit the effects of *summation* and *chronaxy* somewhat analogous to like functions of living nerves. Even if one were inclined to admit a consciousness in the iron wire "nerve" he would not agree that it could feel pain after the fashion of an individual with a cinder in his eye. On the other hand, to deny that human beings suffer in this latter circumstance is to deny what we all know to be fact. Something *does* take place in a nerve which does not exist in the case of the iron wire, but it is not so much what goes on, but what the physiological result might be which concerns us.

Adrian has shown that the quantitative response of a muscle to stimulation of its nerve is in direct proportion to the rate of that muscle's receipt of the nerve impulses. Intense contraction is produced by the receipt of impulses quite closely spaced in time intervals, while lesser degrees of contraction result from more widely spaced impulses. While it is quite difficult to experiment with other living functions to determine whether or not this same law holds true, i. e., that the intensity of response is directly influenced by the shortness of the nervous impulse rate, enough has been done to prove that the law holds for the optic nerve particularly, and for a number of other accessible nerves. By the use of the capillary galvanometer it has been shown that the intensity of light thrown into an eye can be determined by reading the crests of the oscillations as photographed in the camera used in connection with the galvanometer. In some of the writer's research work, under standardized conditions, he has found that it is possible within reasonable limits to determine the kind of light impinging upon the retina by comparing the crests. It has been found that an appreciable time lapse interval is present in the retina between the time when light is

thrown into the eye and the evidence of nerve response shown in the galvanometer. This lag is somewhat too large to be accounted for by the rate of linear nerve impulse transmission. It has been found that during this interval an electrical potential is built up in the retina which, when it reaches a certain value, results in the discharge of an optic nerve impulse. The exact method of the development of this difference in potential is at present somewhat in doubt, although it seems reasonable to believe that in the living eye with its efferent connection to the primary centers that a difference in potential is already existent and that the action of light is merely a photo-electric effect which acts as a lowered resistance path between the higher potential of the efferent fibers distributed to the retina and the afferent fibers of the optic nerve. The lag would, therefore, be somewhat less in the living eye than in the laboratory set-up. The important fact to be borne in mind is that these light stimuli to the retina *actually have an energy value,* otherwise the photo-electric effect were impossible.

In the living eye it is a well known fact that to look steadily at a dimly visible object in a darkened room will eventually cause it to become invisible, but that if the eye be turned so that the image falls on another portion of the retina it immediately reappears, only to disappear after being focused in the new position for a short time. The writer does not believe this to be a true fatigue, believing rather that it is the result of a purely local chemical reduction effect of purely physical cause and that it is limited to the region upon which the object is focused. This presupposes, of course, that the several areas of the retina have some form of *common* efferent connection in conjunction with a highly localized afferent connection and distribution. This thought is further supported by the fact that if the eye be turned so that light is focused on a fresh area the dimly illuminated object again becomes visible. If the eye be held in this position for a few minutes and then returned to the position where the object was found to have become invisible formerly, it will be found that the experimenter will again see the dimly lighted object on the area of the retina where it was invisible before. This phenomenon can be explained on the basis of reversible transformations of the voltaic photo-cell as observed by *Jaeger,* in which after the lapse of time, in the absence of light, the photo-electric effect can be again demonstrated in the cell which had lost its ability by exposure to light. This reversible transformation takes place under the influence of the lower frequencies of light at approximately the same rate as does in darkness. *This is important.*

It remained for *Plank* in his investigations of black body radiation to attempt to reconcile certain experimentally determined facts with certain mathematically possible conclusions. The only, to him, possible solution was in hypothecating that light existed in the form of discrete quanta, each possessed of one unit of energy, and also that it were only possible for light to be emitted in these units of energy (quanta). Experimentally and mathematically he determined the value for the

energy of the quantum to be a product of its frequency and h, h a constant having the value 6.55 times 10^{-27} erg seconds. Obviously the *energy of light* of whatever nature or source was and is in direct ratio to its frequency, the higher the frequency the greater the energy content of the light. A later calculation slightly alters the value of h, but in nowise alters the other conclusions.

Now, it has long been accepted by optometrists that the highest visibility in terms of light energy is in the yellow-greens. The writer has done no work looking to his own determinations of this contention, but it has been observed that the higher frequencies excite altered crests as shown by the capillary galvanometer if the light can be kept at photometric equality—like intensities of luminosity, admittedly a rather difficult undertaking, yet a practical possibility with the three frequencies used experimentally. The idea that the optic nerve is capable of transmission of a specific energy for each light frequency is untenable in view of the researches of *Adrian, Lucas, Forbes* and others. The investigations of these men support the "all or none law," i. e., that if a nerve cell responds to stimulus at all, regardless of how slight the stimulus, it reacts to its maximum capacity. If we now consider the refractory period of a nerve (approximately .002 of a second) it is obvious that the number of types of impulses possible to be carried over a nerve fiber is extremely limited, hence it is difficult to adequately account for sense perceptions differentiating the low frequencies from the higher frequencies except on some basis akin to modulation as suggested by *Troland*. The writer does not believe, however, that *Troland's* suggested specifically tuned receptors is tenable because *Head* has shown that stabilized localization of function does not exist in the human body. Furthermore, *Lashley* has shown that the center of vision may actually shift around in the cortex. The foregoing discussion leads us, to quote *Reiser*, "to the conclusion that the notion of rhythms or frequencies of neuronic discharge is the only adequate substitute for the doctrine of specific energies." This contention has received some experimental support by *Lillie* and was first propounded by *Lapicque*.

The characteristic discharge frequency as a result of a stimulus is determined by three factors: a. The frequency of the efferent charging frequency (the current establishing a difference in potential); b. The discharging frequency of the afferent cell and neurone; and c. The energy content of the incident stimulus. The mechanism whereby the discharged frequencies are determined is largely dependent upon the semi-permeable nature of the surface of a living cell which is presumed to be a double layer of ionized molecules attached to the surface of the cell. In the absence of a stimulus the molecules in this layer assume a very definite relationship determined by the electrical stabilization to each other by their respective positions. The point of application of the stimulus becomes negatively charged at the instant of application, thus distrubing the electric equilibrium of the cell. The frequency with

which the equilibrium may be disturbed, the setting-up of afferent discharge frequencies, bears a mathematical relationship to the intensity of the electrical potentials involved and the frequency of the efferent charge.

From the foregoing the first conclusion to be drawn is that the energy content of light has some other effect than that of vision alone. have been learned about the phenomena under discussion.
Clinically this seems to have been amply demonstrated, although admission is here made that much work remains to be done before all facts

Light frequencies depend upon differential absorption of light by matter. As one author states it, "absorption is in reality perpetual internal reflexion within molecules, the light absorbed being of such wave-lengths as to always be so reflected as to make escape impossible." But whatever the exact mechanism, the fact remains that some sort of resonance exists within the transmitting or reflecting medium by means of which certain frequencies are absorbed and the observer senses the complementary.

Carbon and its compounds exhibit most unusual properties with reference to light frequencies. Most of the carbon compounds are what might be termed "saturated" in that there no longer remains any affinity for other substances. Such compounds are colorless. But carbon has an uncanny manner of entering into rather loose combinations with itself, under such conditions, because of the instability of the compound, there is a tendency to acquire hydrogen and oxygen in quantities needed to stabilize the molecule. In these states there is exhibited a selective absorption of light in the visible spectrum. Man is largely a "lump of impure carbon," according to *Russell*, which fact may and probably does account for some of the biochemical reactions to light stimuli within the body, particularly as these stimuli are applied to the eye. Practically all dyes having selective absorption of light become colorless upon reduction, but return to their former quality of selective absorption by the process of oxidation. Rhodopsin has the ability to bleach, or to regain its color under certain well known lighting conditions. Leaving potassium, the only radio-active substance found in the body, completely out of consideration, the writer believes that the foregoing properties of the carbon compounds may eventually explain the phenomena with reference to that mysterious substance, rhodopsin, and that the proper explanation when found will offer full proof of certain matters which are clinically demonstrable, but are most difficult to prove in the laboratory.

Just one instance should be here cited. It is well known that the rate of oxidation of the nerve cell and its axone is increased during activity. The same is also true of the brain. We have seen that compounds capable of selective absorption of light lose that property when reduced and regain it by oxidation. Rhodopsin loses its beautifully phosphorescent-like color upon exposure to white light, and to certain

other frequencies, but retains its color when exposed to red light only —the low frequencies in the visible region. *But* it regains its color when returned to darkness. That is the color returns *if the retina is in contact with the choroid, and not otherwise.* Is there a process of reduction and oxidation taking place here? If so, just what influence does the light energy have upon it? The writer believes that it is possible to explain this phenomena on an electro-chemical basis, having to do with certain polarities of electrical charge. He further believes that in the difference in rate of reduction or oxidation of rhodopsin lies the secret of certain physiological responses to light frequencies. If clinical evidence were the only proof needed to prove his contention, he is prepared with ample evidence, yet he realizes that such evidence carries practically no weight in scientific circles, despite the fact that animal experimentation results in physiological responses practically identical to those found clinically in man.

All life resident in protoplasm is accompanied by electric current. Oxidation and the body oxidized being important factors in the process. Within reasonable limits the rate of oxidation determines the "rate of living." Even consciousness itself is dependent upon the rate of oxidation in the communicating tracts in the cortex. That oxidation in protoplasm is in fact a process of living is cleverly summarized in the following quotation from "Nature," page 910, June, 1926:

"Recent work has shown that molecules are oriented in a surface, so that it may be considered as a mosaic composed of different molecules arranged simply or in groups in a definite pattern, which is characteristic for each cell, but varies with growth and activity. This molecular arrangement will lead to the existence of varying electric fields scattered over the surface of the cell, and the author considers that the molecule is 'activated' and so becomes susceptible of oxidation (or reduction), when it comes under the influence of one of these fields, which causes a shift of electrons from one atom to another of the molecule."

Of course, the simplest chemical reaction is shrouded in mystery, but one of the most acceptable of the suggested explanations of chemical reaction is that some form of radiant energy is necessary, i. e., that light quanta exchanges are necessities for carrying on chemical processes. This thought does not seem so absurd when one recalls present day theories as to just what causes light to be emitted from its source. The "lifting" of an electron from its regular orbit to one farther removed from the nucleus of the atom by means of heat, electrical pressure or other energy, forms the basis for emission of the energy required to accomplish this "lifting process" when the electron falls back to its original orbit, or one of a lower level than the one to which it was forced by the externally applied force, be it heat, chemical or electrical. In other words, light is only emitted by a radiator when electrons lose their absorbed excess energy and *fall back to positions of lower energy content.*

Much time could be spent in discussing the photo-electric effects, but it is believed that enough has been said to show that there is another factor in light which optometrists *must* consider in their work, and that is its *energy content*. To continue longer to think only in terms of "wave optics" and to ignore the obvious "power factor" of light is to ignore and to lose to the profession one of its greatest avenues for expansion and development.

In conclusion then it merely remains to remind hearers that whatever the exact mechanism of transmission to the optic thalamus, the external geniculate bodies, the anterior colliculi and the regularly recognized optic radiation and the associated paths in the cortex, there is also this energy value and its profound effects to be considered. When it is recalled that in the central gray there is received afferent paths from the entire body and that all efferent tracts with one exception (the pyramidal) have direct connection with the central gray, we have a picture of a "master ganglion" which by reason of its many ramifications has undreamed of effects on the preservation, conservation, development and correlation of those functions which bear directly upon effective, efficient and comfortable vision. Perhaps by the next annual meeting it will be possible to bring forth more of the experimentally determined data supportive of this statement, at least the writer now so purposes.

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ARTERIO SCLEROSIS*

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The Optometrist who is skilled in the use of the ophthalmoscope is in a position to render invaluable aid, both to his patient and the family physician by the diagnosis of early arterio sclerosis, as well as other pathological changes which are repeatedly found first within the eye.

It is practically impossible to detect early arterio-sclerosis other than with the ophthalmoscope. Few family physicians are in a position to develop the proper technic in order to observe the early vascular changes of the fundus.

Consequently many of these cases are not recognized until morbid degenerations have hardened and played havoc with vascular systems to the stage of increased blood pressure.

Treatment at this stage often becomes palliative and analagous to locking the stable after the horse is stolen, as the damage is already done.

One of the early ophthalmoscopic symptoms of arterio sclerosis is relaxation and dilation of the arteries. A natural sequence of dilation of the vascular system is probably a lowered blood pressure. Naturally, dilation is followed by tortuosity. Thinning and distension of the vessel walls is soon arrested by proliferation and thickening of the intima, media and adventitia, a process regarded as compensatory. With the advent of this process the disease enters the stages of vascular rigidity and degeneration.[1]

In health a blood vessel is transparent. We see only the blood within the vessel. As with the cornea or lens of the eye an opacity of a blood vessel however slight should be regarded as abnormal.

Translucence or opacity of a blood vessel results in changes in its shade of color, the arteries becoming somewhat of a lighter color. Light lines border the sides of the vessel.

A diagnostic sign of utmost importance in arterio sclerosis is the obscuration of a vein at the point of its crossing under a translucent or opaque artery. The opacity of the artery appears to divide the vein leaving pointed ends on each side of the artery. Increased pressure of an

[1]Diagnosis of the Fundus Oculi. Oatman.

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artery may inhibit the veinous circulation. In this case the distal end of the vein appears as if the blood was of a darker color and a larger size than on the proximal side. The artery acts as a dam to the vein.

As the disease progresses the blood column becomes irregularly narrowed. Some of the vessels seem to dilate in places and in others contracted in its course, assuming a beady appearance.

Many cases of arterio sclerosis are associated with focal infection as well as such diseases as syphilis and kidney trouble. Abnormalities of the retinal vessels calls for careful investigation and treatment by the dentist as well as the family phyician.

A graphic example of the Optometric value of an examination of the eye instead of merely fitting glasses is shown in the following case:

Mr. J. called with no complaint other than his old glasses did not suit him. As far as the symptomatology went this patient was in apparently perfect health, conducting his business as usual.

As the writer will not merely fit a pair of glasses without an examination of the eye, not only for his own protection, but for that of his patient as well, he proceeded as usual with the opthalmoscope and found a surprising astonishingly acute case of arteritis. Practically every retinal artery resembled a string of miscellaneously matched beads. In certain places the artery would narrow down to almost a thread, then dilate irregularly. The veins were found to be in the same condition. All of the retinal vessels were found to be considerably narrowed. This condition could hardly exist as an isolated condition within the eyes. Therefore, we should expect the entire vascular system throughout the body to share in the morbidity.

With a given volumn of blood within the body and the vessels of a certain size and elasticity to maintain a normal blood pressure, should these blood vessels become constricted or lose their healthy elasticity, unless the heart lost its efficiency as a pump we could only expect in these altered conditions to find marked changes in a raised blood pressure.

With the sphygmanometer upon the arm we found the pulse wave at 200 to be very strong. Here a word of caution. With brittle hardened arteries throughout the body we did not consider it safe to increase the blood pressure by the process of determining it, consequently upon reaching the systolic pressure of 200 we immediately released the air pressure of the instrument and immediately sent the patient to his family physician with a report of our findings.

The doctor concurred in our opinion of the gravity of the patient's condition and promptly put him to bed for about three weeks. He found the systolic pressure about 220.

The infection which caused the arteritis was found in the teeth (pyorrhea) and the prostate gland. About one month treatment (dental and medical) resulted to our astonishment in a normal blood pressure

and an apparent cure of the arteritis.

The Relation of the Size of Retinal Vessels to the Blood Pressure in Healthy Patients

As above stated, with a given volume of blood in vessels of a certain size to maintain a normal blood pressure, should these vessels shrink upon the blood stream within them we then should expect a higher blood pressure.

Owing to this pathological sequence of high blood pressure where shrunken retinal vessels are found, about a year ago we concluded that the opposite should hold true when these vessels appeared larger than usual. Consequently we have found so far without exception that in cases where all of the retinal vessels were much enlarged that the blood pressure was proportionately lowered, and the greater the dilation the lower the blood pressure.

This rule will not hold true in cases where the veins are enlarged and the arteries small, as this is evidence of disease. Venous distension may be the logalical result of arterial rigidity and narrowing. The blood being forced out of compressed arteries is driven into the veins, they naturally increase in tortuosity and the blood pressure may be high.

With practice one may not only infer from the retinal picture before him whether the blood pressure is high or low, he is able to approximate how low it is.

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A NEW PUPILLOMETER*

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The fields of the more popular sciences have never been without adequate and ofttimes blatant press-agentry. Does someone invent a new gadget to go on a radio set, a worthless whoofus to attach to the lawn-mower or an automatic self-ejecting button-hook, it is at once blasted into attention by the medium of a half-score of pseudo-scientific magazines. Concurrently, but unknown to the public at large, new and improved and revolutionary developments continue to be made in the more accredited laboratory sciences, processes and inventions which are destined to be of more human service than outsiders have any realization. Of such stature is the pupillometer, recently brought out by a St. Paul optical inventor and engineer.

Within the profession it is a well-recognized phenomenon that no pair of eyes is in perfect balance, that one eye is nearly always found to be farther from the nose than the other, a fact of which account is taken in any attentive fitting of glasses. In many cases this disparity is of such slight proportions that it is a matter of simple correction by the optometrist fitting glasses. But in more extreme cases the difference is so great that in order to achieve and maintain the maximum benefit from glasses the distance must be accurately measured in order that the focal center of the lens be adjusted in direct alignment with the pupillary center of the eye. The pupillometer facilitates this objective by providing an improved and simplified means of ascertaining the precise position of the pupillary center of a patient's eye and the pupillary distances on either side of the nose. Other and more rudimentary appliances have sought to do this, but it is believed by the inventor that none have offered the refined determinations which the present pupillometer affords.

The accompanying cuts, somewhat self-explanatory, show that the essence of the pupillometer is a pair of horizontal sighting tubes, spaced parallel and as far apart as the average distance between the eyes. A movable gate makes it possible to cut off vision through either tube at will, and below the tubes is an electric light chamber illuminating the

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Pupillometer

Pupillometer

ends of the tubes. A handwheel in the base provides adjustment for height.

At the patient's end of the instrument is an inverted V-shaped recess against which the bridge of the nose is rested. On either side of it is a fine hair-wire arranged to be moved across the pupil by a micrometric thumb screw. Below each wire is an accurately graduated scale giving in metric units the distance of the wire from the nose. A box-like affair at the operator's end of the instrument accommodates two pairs of lenses, one pair being of one diopter and the other of two diopters, thus giving a corrective possibility in the operator's vision of one, two or three diopters. Just inside the operator's end of the tubes is a small sighting disc as a point of concentration for the patient's eyes. It is because these sighting discs are mounted on a bar obscuring the lower half of the tubes that the auxiliary lenses are of the split variety, as shown in the cut. A further function of this supporting bar is to shield the operator's eyes from the direct light of the lamp housing.

When the pupillometer is in use the patient is instructed to rest the bridge of his nose against the specially provided groove, which is of fibre for comfort. The gate is slid up, to shut off one of the tubes and the electric light in the base illumines both the sighting discs at the one end and the patient's eyes at the other. As the patient is asked to fix his gaze on the sighting disc at the opposite end of the tube, the operator turns one of the thumb screws until its corresponding wire exactly bisects the nearby pupil, and the distance from the nose is then read directly from the scale. With the gate swung to the other tube, the process is repeated with the other eye.

The pupillometer is finished in the popular crackle enamel and despite the delicacy of its work it is of rugged, substantial construction, not calculated to be easily knocked out of order.

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OPTOMETRIC EDUCATION*

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This article is an attempt to analyze the professional responsibilities of Optometry as I have found them in my ten years of practice and to determine to what extent these responsibilities are recognized by the educational institutions of Optometry.

An adequate program of optometrical education must recognize all phases of responsibility in optometrical practice and emphasize in its curriculum the various factors in the relative importance as found in actual experience and practice. I submit the following as a summary of the diagnostic responsibilities of the optometrist of today. The first responsibility is for the refractive diagnosis, the second for diagnosis and treatment of the so-called "muscle cases," the third, the recognition of the relationship of general pathology to eye symptoms, and fourth, the recognition of local eye pathology. I do not find an urgent demand for optometrical service which is contingent upon specialized courses in physics and theoretical optics as professional requirements.

It is my contention that the optometrical education of this decade fails to prepare students adequately to meet the responsibilities of recognition of the relationship of general pathology to eye symptoms and some institutions also fail to teach the modern principles of diagnosis and treatment of muscle cases.

The major objective in this article is concerned with the relationship between systemic pathology and eye symptoms. However, at this point I will take the liberty of presenting my own personal experience in relation to the diagnosis of muscle cases. In the last five years I believe that I have diagnosed not less than five hundred cases of muscular defects and to the best of my knowledge I know of only three or four cases which have had trouble with a prism correction. The majority of these cases I have seen one and two years after prescribing prisms for them and the results have been uniformly satisfactory. When an optometrist says that prisms are poison and to be avoided he is telling the truth because any therapeutical reagent that is not properly applied is poison. Radium is a wonderful contribution to human happiness when rightly

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applied, yet when a patent medicine company sold radium salts in a liquid as a tonic, the consumer met a terrible death.

The order in which I have placed these responsibilities is in the sequence of their importance as found in practice in my own experience. I believe that an adequate educational program should take these factors into consideration in order of their importance as a basis for selection of the subject matter taught in our schools of Optometry.

During my first year in practice I kept an accurate record of the number of people who consulted me for eye difficulties which were diagnosed as not needing glasses. I discovered that ten per cent did not need glasses. And of this ten per cent more than half were having trouble due to the relationship of some general pathology to eye symptoms. I have found in subsequent years that the majority of pathological cases presenting themselves to an optometrist are general and not local eye pathological cases. Furthermore, the recognition of general pathology as related to eye symptoms requires a much broader knowledge of the fundamental medical sciences and a wider appreciation of medical diagnosis than does the recognition of local eye pathology.

Headaches and discomfort about the eyes cover a multitude of physical causes. Whether or not a given headache is caused by the need of a plus twenty-five or fifty spheres or by a heart, kidney, thyroid, or sinus condition should be a very vital question to any optometrist desiring to be recognized as a professional man. Of course if one's sole object is to sell glasses such consideration can be lightly dismissed.

Not so long ago a lady consulted a professional optometrist about her eyes. She had been suffering for some time with a very severe headache. He told her that a change in glasses would do her no good since the cause of her headaches was not in her eyes. Then she told him that her physician had advised her that the cause of her trouble was due to thyroid difficulty and that glasses would do no good. But she was gullible and fell prey to the blatant advertising of a commercial optometrist. He blithely assured her that if she would wear his glasses for two weeks her headaches would disappear. When she consulted him later it was just too bad, but nothing could be done about it. Is it any wonder that some medical doctors apparently have an unreasonable prejudice against Optometry? If such malpractice occurs with optometrists who hold positions of responsibility the status of optometry in the opinion of the public and of the medical profession is depreciated.

The optometrist of today leaves school fairly well equipped to recognize local eye pathology, but optometrical instruction does not contain any courses relative to the relationship between general pathology and eye symptoms which is far more frequently met with in actual practice than is local eye pathology. Some schools even go so far as to lay a good foundation in the fundamental medical sciences (anatomy, histology, physiology, bacteriology, and pathology), but fail to build the superstructure upon the foundation they have laid. Courses in the

fundamental medical sciences should be complemented by courses in general diseases as related to eye symptoms and the pathology of nose, throat, and ear as well as eye. I am not proposing that optometrists diagnose or treat either local or systemic pathology as related to the eyes for several reasons, the most important of which is the consideration that the laws of the several states definitely limit the practice of Optometry. My proposition is merely that Optometry definitely prepare its students to RECOGNIZE general as well as local pathology as related to the eyes.

If Optometry is to be limited to the proposition that the human eye is like a camera and has no connection with general pathology, it is a waste of time to equip the student with an understanding of the fundamental medical subjects when he is prohibited from acquiring the practical appliances of the fundamental medical subjects.

There are some optometrists, knowing that Osteopathy has converted itself over from a strictly non-medical profession to a limited medical and surgical profession, who propose that Optometry shall become a limited practice of medicine with respect to the eyes. If Optometry is to become a limited practice of medicine there is ample time to consider this after Optometry has created educational facilities to give her students adequate instruction in medical subjects and properly qualify them to recognize general pathology in relation to eye symptoms. The field of Optometry is broad enough to demand the concentration of energy of the best man if he assumes the responsibility of refractive and muscular diagnosis and the recognition of local as well as general pathology in relation to the eyes.

I think the ideal optometrical education should consist of four years' work and in the first two years the major activity should be medical courses in anatomy, histology, pathology and physiology. In the last two years the optometrical studies proper with special courses in texts and clinic upon general pathology as related to eye and local eye, nose and throat pathology, in addition to special work on anatomy and physiology and embryology of the eye which latter could easily be included with the first two years' work.

Four years would be sufficient time for this proposed curriculum when the physics, theoretical optics of telescopes and what-nots are treated in proportion to their contribution to a successful professional optometric practice. The degree should be a doctorate even if the school has to be independent and only using the facilities of the larger universities for the instruction in the first two years. In the course of time if Optometry feels able to meet the qualifications specified for a doctorate degree by the universities of the land, a one or two year cultural preoptometrical course can be introduced. This process of growth is identical with that pursued by all other professions. Optometry is the only profession which has permitted an alien domination of her educational institutions with the cart before the horse idea of education in which the professional work is given for a bachelor's degree and the doctors awarded

for strictly graduate work. This domination of academicians has prevented the schools in large universities from being known as Optometry Schools or from obtaining a bachelor's degree in Optometry, when by all rights a doctorate degree in Optometry is appropriate.

An adequate preparation in medical work enabling an optometrist to recognize general pathology as well as local pathology in relation to the eyes would eventually disarm medical opposition and make possible a general cooperation between the professions. Optometry would come to stand in the same relation to medicine with respect to the eye as dentistry does to medicine in relation to the teeth. Eventually, refractive positions in hospitals and other health agencies would be open to optometrists and they would learn to consult with medical and dental practitioners regarding pathological cases.

Any general recognition of Optometry by the medical profession as qualified to diagnose refractive errors cannot be expected until Optometry recognizes the importance of general pathology sufficiently to give ADEQUATE INSTRUCTION IN OPTOMETRICAL SCHOOLS in medical subjects. Any general recognition on the part of medicine cannot be won by the work of a few optometrists alone. Such recognition is also contingent upon the success of Optometry ridding itself of the evils of commercialism and lay domination. And I am glad that I can observe vigorous action along this particular line.

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POSSIBLE SYNDROMES OF OCULAR NEURO-MUSCULAR DEFECTS

In all specialties various diagnostic signs are sought for, which may evidence or indicate certain changes from the normal expecteds. This is true in refractive work and it is also true in myologic treatment work. Case histories are carefully taken and many phases of ocular refractive procedure are followed to determine wherein abnormalities may be found and to ascertain just what corrective measurers must be taken to effect a cure, or at least relief.

Experience has taught us that certain factors or combination of factors indicate a possibility towards a defect or an actual defect itself and these combinations of signs or syndromes are sought for by all optometrists.

Hammond[1] in a paper presented before the American Academy of

[1]W. H. Hammond. Harmonizing the Ocular Functions. Vol. 1, American Academy of Optometry. pp 25-40. 1926.

Optometry several years ago outlined sixteen symptoms which when observed by optometrists should act as possible symptoms of ocular neuro-muscular defects. He claimed that when found, any of these sixteen syndromes of neuro-muscular defects as a rule indicate the need for myologic treatment work, even in the event that the patients eyes may be emmetropic or made so with a correction. Hammonds syndromes are as follows:

1. A wavering and unsteady gaze.
2. Turning the head sideways when fixing the gaze.
3. Tendency to close one eye.
4. Muscular contraction of facial muscles when looking or fixing.
5. One side of face higher than the other.
6. General manifest lack of interest when looking at an object.
7. General aversion to study.
8. Watering of the eyes, except that produced by temperature, shock, or an obstruction of canal.
9. Drowsiness in using the eyes at a close range.
10. Nervousness associated when taxing the eyes.
11. Digestive disturbance when taxing the eyes.
12. Elevated eyebrows with expressionless face.
13. Failure of upper lids to follow eyeball when looking down.
14. Car sickness.
15. After effects of going to movies.
16. Usually "done-up" next day after going to a party, into a crowd or shopping.

C. C. K.

* * * * *

MR. ADOLPH LOMB

This month records the passing of another of the great leaders of that group comprising the manufacturers of ophthalmic equipment. A man who has ever been in the front rank in inspiring scientific research and in improving conditions throughout the Optical World, which will indeed miss him greatly. Adolph Lomb, vice president of the Bausch & Lomb Optical Co., died at his home in Pittsford, N. Y., a surburb of Rochester, September 30, after a brief illness. He was 66 years old.

Mr. Lomb, the eldest son of the late Capt. Henry Lomb, had been connected with the optical institution established by his father and the late John Jacob Bausch for 53 years. Mr. Lomb was identified with a number of scientific and patriotic societies, chief among which was the Optical Society of America. He had been treasurer of that organization since its inception and one of its most beneficient financial supporters. Mr. Lomb, who was born in Rochester in 1866, was a graduate of the University of Rochester, class of 1892, and had also taken advanced work at the Massachusetts Institute of Technology and the University of Berlin, Germany.

He leaves his mother, Mrs. Emile Klein Lomb, widow of Capt. Henry Lomb. A brother, Henry C. Lomb, of New York City, a nephew and two nieces. Mr. Lomb was unmarried. Funeral services were held on Monday, October 3, with interment in Mount Hope Cemetery, Rochester.

C. C. K.

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PROFESSOR LEONARD T. TROLAND

All those who knew Professor Troland are shocked to learn of his untimely death. His death is a great loss not only to his friends and associates but to the entire scientific world. He was born in Norwich, Conn., April 26, 1889, graduated from Massachusetts Institute of Technology, receiving his B.S. degree in 1912. He then studied psychology at Harvard under Professor Muenstenberg, receiving his M.A. in 1914 and Ph.D. degree in 1915. Following this he spent several years at the Nela Research Laboratory in Cleveland, where he carried out optical investigations in relation to light and vision. During the years 1913 to 1916 he published fifteen scientific papers dealing with physiology and psychological optics. He later returned to Harvard where he became professor and lecturer in psychology until the time of the of the accident at Mt. Wilson, Cal., where he fell to his death by losing his balance while standing on the edge of a rocky chasm.

Troland was in indefatigable worker. He took all sciences as his field. He was a master in chemistry, physics, biology and psychology. His chief interest was in the investigation of the "Visual Phenomena." A volume on this subject he published in 1929. While he was only 42 years old at the time of his death he was recognized as an authority in his field. He wrote many scientific articles and books. Some of these are: "The Nature of Matter and Electricity" in collaboration with Dr. Comstock (Van Nostrand 1917); "The Present Status of Visual Science" (Bulletin Nat. Res. Council 1922); "The Mystery of Mind" (Van Nostrand 1925); "The Fundamentals of Human Motivation" (Van Nostrand 1928) and last he published four volumes upon "The Principals of Psychophysiology." A number of chapters in these books dealing with visual sensations and visual perceptions.

He was a frequent contributor to the American Journal of Physiological Optics and he assisted in the English translation of Helmholtz's "Handbuch der Physiologishen Optik." Troland was a friend of Optometry and on several occasions lectured before Optometric organizations. He was a distinguished member of many scientific societies and always took a leading part in their proceedings. He was president of the Optical Society of America in 1922 and for several years served as a member of the National Research Council on Physiological Optics.

Science in general and Physiologic Optics in particular sustained an irreparable loss in the untimely death of Professor Leonard T. Troland.

J. I. K.

ANNOTATIONS
AND
SOCIETY PROCEEDINGS

The American Journal of Optometry is the Official Organ of the American Academy of Optometry, as well as the Organ of the Arkansas, Delaware, Indiana, Iowa, Maine, Maryland, Michigan, Minnesota, Nebraska, North Dakota, Oklahoma, Pennsylvania, South Dakota, Vermont and West Virginia Optometric Associations.

The following gentlemen have consented to supply items of interest from their respective sections, acting in the capacity of

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ON MAKING OPTOMERIC CONSULTATIONS

At a recent meeting an optometrist mentioned sending a patient to an ophthalmologist for an ocular refraction. He did this he claimed because he found the case too difficult for him to handle. What a mistake! In the first place the chances are that the ophthalmologist to whom the case was sent had less refractive training than did the optometrist. In the second place he probably had less equipment to assist him in making a diagnosis and in the third place he was probably much less interested in refraction than was the optometrist. Here is a classic example of short-sightedness and laziness.

To review this matter from another angle, the optometrist in referring this case as he did admitted a lack of technical training which naturally lowered him in the eyes of the patient and in addition to this he lost the case. To be sure the patient may have returned to him with a prescription for him to fill but the fact remains that the case is, from that time on, a case belonging to the ophthalmologist. Not only has this case

been lost to the ophthalmologist but it is fairly certain that the entire family of the patient is lost as well. What a price to pay for the lack of foresight and the lack of willingness to work out the problem to a successful conclusion. What if it was a difficult case. These are the interesting ones and remember someone has to work them out successfully. It may as well be you or it may as well be done under your direction.

If the case is so difficult that you feel you cannot do it alone there is a legitimate thing you can do without losing the case and which will add rather than detract from your prestige. In every community there is some one outstanding optometric refractionist. In cases of this sort this man should be called in to consult with the optometrist about the case. Have him come to your office and examine the case with you. Then you both work out a course of procedure together. In most instances the patient will gladly pay the extra fee for the consultation or if not it will be money well spent for the optometrist to pay it himself rather than lose the patient, his family and possibly his friends as well.

To send patients to ophthalmologists for treatment of pathology is one thing: To send them for an ocular refraction is another. We naturally must co-operate to the fullest extent with the ophthalmologist but it is the height of folly to refer to that group the type of case in which we as opometrists excell: that is, the diagnosis of refractive errors.

C. C. K.

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ESSEX COUNTY SOCIETY

At a meeting of the Essex County Optometric Society held in Newark October 7th it was decided to incorporate the Essex County Free Optometric Clinic as a non-pecuniary charitable organization, to be controlled by the Society itself. A special meeting for this purpose was held October 28th and the entire matter was approved by the society meeting as a whole. The clinic is in operation on Tuesdays and Thursdays of each week from 9:00 a. m. until noon, under the direction of Dr. Charles E. Jaeckle, and a staff of clinicians.

* * * * *

EYE-GLASS MOUNTING FOR MUSEUM

During the Civil War and shortly afterwards, the Bausch & Lomb Optical Company was manufacturing a product that was called the "Number 21 Rubber Eyeglass." As this was one of the earliest Bausch & Lomb ophthalmic mountings, the company is anxious to obtain a specimen for its own museum. If you have one or know where one may be obtained, please communicate with Mr. Edward Bausch, President, Bausch & Lomb Optical Company, Rochester, N. Y.

BACK COPIES WANTED

Dr. Robert K. Palmer, 18 N. Main street, Barre, Vt., would like to secure volumes 1 to 5, inclusive, of the American Journal of Optometry. These volumes representing the years 1924 to 1928 are entirely out of print and any person having these copies and wishing to dispose of them is requested to communicate with Dr. Palmer.

* * * * *

COUNCIL OF MID-WEST CONGRESS

The executive council of the Mid-West Congress of optometrists met in Omaha on September 4th to plan their educational activities for 1933. The states represented at this meeting were Colorado, Minnesota, Oklahoma, Nebraska, Iowa, South Dakota and Missouri. After some discussion it was decided to invite Dr. Harry L. Foug of Los Angeles, Cal., to be the guest speaker for 1933 and in the event that Dr. Foug found himself unable to accept that Dr. John Zug of Carnegie, Pa., be invited. The state of North Dakota was also officially invited to participate in the activities of the Congress.

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HENNEPIN COUNTY SOCIETY

The November meeting of the Hennepin County Optometric Society will be held at the Elks Club in Minneapolis on November 10th at 6:30 p. m. Dr. Henry Watzke of Morris, Minn., will be the guest speaker. Dr. Watzke is president of the Minnesota State Association of Optometrists.

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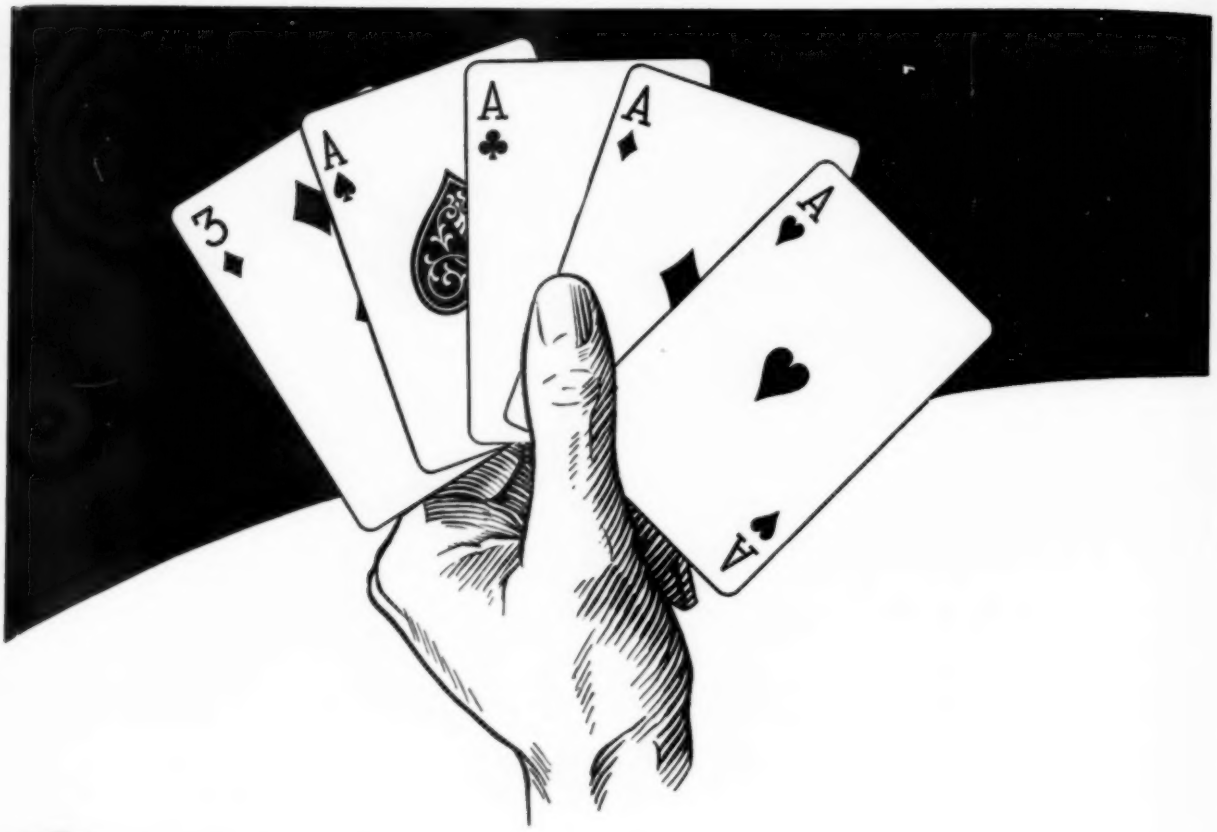
NEW YORK ACADEMY OF OPTOMETRY

The New York Academy of Optometry will hold an open meeting to invited guests on Tuesday, November 22, 1932, at the Physics Laboratories, Columbia University. The lecturer for the day will be Professor Edwin Forbes Tait, of the Faculty of the Pennsylvania State College of Optometry. He will present, by invitation, his original researches in the field of "Accommodative-Convergence Relationships."

The lecture will start promptly at 2:00 P.M. and continue intermittently until 5:30 P.M., time being allotted for discussion and recess. Dinner will be served at 6:00 P.M. sharp, at the Men's Faculty Club on the campus. The lecture will resume at 8:00 P.M. and continue until 9:30 P.M.

Invitations may be obtained from the Secretary of the Academy, W. B. Blee, 24 Arlington Place, Brooklyn, New York.



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